HDTV 1125/60 GROUP

A PRODUCTION STANDARD FOR THE WORLD.

November 30, 1988

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Federal Communications Commission
Office of the Secretary

Mr. H. Walker Feaster, III
Office of the Secretary
Federal Communications Commission
Washington, D.C. 20054

Dear Mr. Feaster:

Enclosed are the original and nine (9) copies of Comments of The HDTV 1125/60 Group In Response To The Tentative Decision and Further Notice of Inquiry MM Docket No. 87-268.

Very truly yours,

William G. Connolly

William G. Connolly

Enclosures

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BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of

Advanced Television Systems and Their Impact on the Existing Television Broadcast Service	)	
Review of Technical and Operational Requirements: Part 73-E, Television Broadcast Stations	)	MM Docket No. 87-268
Reevaluation of the UHF Television Channel and Distance Separation Requirements of Part 73 of the Commission's Rules	)	

COMMENTS OF THE HDTV 1125/60 GROUP IN RESPONSE TO TENTATIVE DECISION AND FURTHER NOTICE OF INQUIRY

November 30, 1988

I. INTRODUCTION

The HDTV 1125/60 Group is an organization of manufacturers and users of HDTV 1125/60 production equipment. The primary purpose of the HDTV 1125/60 Group is to enhance U.S. program production opportunities and stimulate a broad participation by U.S. manufacturers by actively supporting the 1125/60 production standard for HDTV studio origination and program exchange.

Among the members of the HDTV 1125/60 Group, the manufacturers who currently offer or intend to offer production equipment utilizing the ATSC/SMPTE HDTV 1125/60 production standard are: Chyron; Cinema Products; ColorGraphics Systems, Inc.; Compression Labs, Inc.; Dynair Electronics, Inc.; Dynatech Broadcast Group; Fujitsu America, Inc.; Grass Valley Group; Hitachi America; Ikegami Electronics; Magni Systems, Inc.; Matsushita Electronics Corporation; Mitsubishi Electronics; NEC America; NEC Home Electronics; Panavision; Pioneer Electronics, Inc.; Quanta Corporation; Quantel, Inc.; Rank Cintel, Inc.; Rebo Studios; Sanyo Fisher Corporation; Sharp Electronics Corporation; Sony Corporation of America; Symbolics Graphics; Teknika Electronics Corporation; Toshiba America, Inc.; Ultimatte Corporation; Utah Scientific; and U.S. JVC.

Among the advisors, companies that use the HDTV 1125/60 production system, are 24 companies and organizations in the academic, production, cable, programming and broadcasting industries. All member companies and advisors operate within the U.S. economy.

The Commission's September 1 Tentative Decision and Further Notice of Inquiry seeks comment on the 1125/60 standard and its compatibility with other proposed production systems and with various transmission systems. These comments are based on the experience of the HDTV 1125/60 Group members and advisers in the development of the ATSC/SMPTE 1125/60 production standard and their work with the system both within the manufacturing environment and in its application to program production.

The reconciliation of a powerful new HDTV imaging system with a 40 year old extensively entrenched 525 NTSC television system is not an easy task. This must be clearly recognized at the outset. It is highly tempting to curtail the true prowess of HDTV to ameliorate the technical aspects of relating the two. We urge the opposite. We strongly recommend a very long term view that attempts to anticipate the enormous potential of HDTV electronic imaging across the broad spectrum of industries. HDTV promises exciting enhancements to future home entertainment. HDTV also signifies dramatic advances within the thousands of industries currently harnessing the dual power of television imaging with computer processing. This latter dynamic did not exist in 1953, when the 525 NTSC color system was born. It is an enormous dynamic in the 1980's -- and is growing at an unprecedented pace.

An HDTV production standard has a universal meaning today that is not yet clearly appreciated. Our group urges that this be closely examined during the current Inquiry.

II. A SINGLE WORLD STANDARD FOR PROGRAM PRODUCTION WAS THE MANDATE OF THE NINE BROADCAST UNIONS OF THE WORLD.

"We seek a single worldwide standard for studio origination and international program exchange." That was the mandate of the nine broadcast unions of the world when they convened in Algiers in 1983. None of the world's nine broadcasting unions, including our own North American NANBA, have waivered from that objective. Following years of extensive global study and debate, the 1125/60 format has emerged as a strong contender. In fact, it remains the strongest contender. Its viability as a single worldwide HDTV production standard rests on the fact that it is not exclusively "friendly" to any one existing television broadcast standard but, rather, accommodates all present and future channels of program distribution, including U.S. terrestrial broadcasting.

The widely expected increase in future international co-production of television programs will be considerably facilitated by the sharing of a single HDTV studio origination standard. <u>The preeminent U.S. program production industry (generally called "Hollywood") will be a major beneficiary of a single worldwide standard for international program exchange</u>.

III. THE WIDEST APPLICATION OF 1125/60 TECHNOLOGY WILL BRING DOWN COSTS FOR ALL USERS.

Extensive and diverse use of the 1125/60 studio standard will be the most profound influence on bringing down the costs of equipment

for broadcasters and all other users. The HDTV 1125/60 system has been designed to meet the needs of many industries with diverse applications, such as electronic cinematography, flight simulation, medical, image storage and retrieval, printing/publishing, information banks, and many more. In addition, the worldwide aspect of HDTV 1125/60 generates a potential for large scale production of cameras, VTRs, and other "big ticket" items with attendant economies of scale.

IV. THE SMPTE/ATSC REFINEMENT OF THE 1125/60 SYSTEM

The primary scanning parameters of the HDTV 1125/60 production standard have changed little since the initial proposal was made in the late 1970's. This testifies to the soundness of the underlying research and the global perspective embodied in the original proposal. The very sound basis in extensive psychophysical testing places 1125/60 on very firm foundation. However, important issues of colorimetry, transfer characteristic, aspect ratio, interlace, sync and blanking waveforms, digital coding and equipment interconnectability have since been studied and refined by a wide cross section of American experts.

The American review process first brought HDTV under the consideration of the Society of Motion Picture and Television Engineers (SMPTE) within the Study Group formed in 1976. In 1982, the Working Group on High Definition Electronic Production (WGHDEP) brought together a large cross-section of industry experts. These included broadcasters interested in HDTV video production and

conversion to existing and future distribution standards, motion picture engineers looking to ensure the highest standards of image quality, and equipment manufacturers with access to extensive research and design facilities.

They started by examining a variety of proposed systems and parameters that would lead to a single unified HDTV production standard. Their aim was a standard that would embrace all of the following applications: high quality HDTV video production, transfers from HDTV origination to 35mm film, transfers from 35mm film to HDTV, computer graphics and graphic arts and downconversion to existing broadcast TV standards.

In 1983, the High Definition Technology group of the newly formed Advanced Television Systems Committee (ATSC) also began its search for a single voluntary U.S. standard for a future HDTV system.

The next five years saw a close collaboration between the SMPTE and the ATSC. A variety of HDTV proponents systems were investigated. In the end, a highly refined and expanded version of the 1125/60 system yielded the closest match to the joint goals of ATSC and SMPTE. The result is nothing less that the world's most thoroughly defined television system from camera pickup to final display.

Following careful review, the general membership of the ATSC endorsed these same parameters by the necessary two-thirds majority on January 6, 1988. On that day, 1125/60 became an ATSC voluntary national standard for HDTV studio origination and program exchange. While the scanning fundamentals of the originally proposed 1125/60/2:1

scanning format remain essentially unchanged, the SMPTE/ATSC standard includes many significant additions and improvements that considerably extend the applicability of the production standard. What is more, the SMPTE/ATSC HDTV signal structure is coherent with the 4:2:2 digital coding format specified by CCIR Recommendation 601.

A specially formed subgroup of WGHDEP did extensive studies to determine the optimum aspect ratio. Both video and film experts were active participants in this search. As a result of this complex task, the aspect ratio was widened from the original proposal of 5:3 to the wider 16:9. The new aspect ratio fulfills four important objectives: provides flexibility in different film format releases when shoot and protect techniques are used, uniformly distributes the protected area about the wide screen action area, provides a release film (when transferred from HDTV) that is compatibly framed for existing cinema projectors having apertures of 1.85 and 1.66, and provides better coherence with the digital CCIR Recommendation 601.

Both ATSC and SMPTE identified a potential problem for implementing the HDTV 1125/60 systems: different synchronizing waveforms from various 1125/60 equipment manufacturers. ATSC and SMPTE searched for a single sync waveform standard that would ensure system connectability. Other concerns were precise synchronization and relative timing of the three component video signals and a structure robust enough to survive multi-generation recording.

The WHGDEP revised the horizontal blanking interval to accommodate a dramatically improved sync waveform. The final decision involved a highly complex relationship among five factors: aspect ratio, digital

coding and sampling frequency, preservation of geometric compatibility with existing 5:3 aspect ratio software, practical limitations in camera and monitor scanning circuits and characteristics of the new sync waveform. But again, the SMPTE and ATSC experts established a horizontal blanking interval that accomplished every goal.

The SMPTE/ATSC standard sync is a trilevel bipolar waveform with a large horizontal timing edge occupying the center of the video signal's dynamic range. To permit the implementation of a highly precise, minimum jitter sync separator system, the timing edge has a precisely defined midpoint centered about the video blanking level. This new sync system was extensively tested. Timing accuracy is superb even in noisy environments. This new sync works with both simple sync separators and with the more sophisticated circuits.

While refining the basic parameters of the scanning format, the SMPTE was also examining electro-optical transfer and system colorimetry. In NTSC, the highly non-linear transfer characteristic of studio monitors and home TV receivers forces us to pre-correct with electronic "gamma correction" in TV cameras. While this system works as intended, it could not accommodate the gamma characteristics of future HDTV display using LCD, laser, plasma and other technologies yet to be invented.

The SMPTE Working Group also considered the demand for improved colorimetry to ensure high quality film/HDTV interchange, to provide enhanced TV display and to meet the requirements for digital implementation. These demands led the Working Group to specify the camera transfer characteristic with high mathematical precision. This

will guide HDTV camera designers toward a predictable and unified specification. Linearization of the signal can now be performed precisely -- thus permitting digital processing on linear signals when required.

The Working Group achieved a comprehensive definition of a total system of television colorimetry. It begins with a substantially broader spectral taking characteristic that promises to revolutionize film/tape interchange. Colorimetry and gamma are precisely specified throughout the reproduction chain.

NTSC color television has always had a less expressive color palette than color photography. More than just a philosophical issue, this constraint becomes a practical concern whenever the broad color gamut of film is transferred onto the narrower color gamut of today's television.

A broader color gamut, long thought desirable for broadcasting, is absolutely essential for a better fit with the capabilities of computer graphics and tape-to-film transfer. These requirements made SMPTE determined to establish improved colorimetry for HDTV 1125/60.

The difficulties in fully describing television colorimetry are well known -- they had mitigated against any practical emergence of a standard for colorimetry within our present 525 line system. However, the combined effort of the film and video industries has now achieved a standard for HDTV production. For the first time in TV history, a total colorimetric specification -- from camera origination to final display -- is defined with precision. SMPTE took a highly pragmatic -- but quite ingenious -- two-step approach.

In the near term, the SMPTE standard takes a giant step toward coordinating all HDTV cameras and monitors. All HDTV monitor manufacturers are urged to conform to a single phosphor set: the SMPTE C phosphors that are now the de facto standard in North America for 525 studio monitors. All camera manufacturers are urged to conform HDTV camera colorimetry to a SMPTE C reference primary and to a D65 reference white. All camera manufacturers would incorporate a non-linear transfer circuit of precise mathematical definition. The first cameras and monitors conforming to this standard were shown at the NAB convention in April 1988 -- a testament to the accepted recognition of the wisdom of this standard.

Step Two will make the more dramatic leap toward a wide color gamut colorimetry -- defined from camera origination through to final display. In addition, Step Two will ensure accurate and equal reproduction on displays employing vastly different technologies.

It calls for the unprecedented use of new non-linear electronic processing within the display. First, the source HDTV component signal is linearized (which can now be accurately implemented because of the precisely specified camera nonlinear transfer characteristic), then decoded to RGB, if necessary. Then the signal is tailored to the specific electro-optical characteristics of the display via linear matrix and gamma correction circuits. As a result, the full range of current and future display devices (direct-view CRT, projection CRT, light valve, electro-luminescent, etc.) can portray identical colorimetry within the individual constraints of each display's technology. The standard also fully anticipates future improvements in the color gamut capabilities of display devices.

Taken as a whole, the SMPTE 1125/60 standard is grounded in practical reality and the best scientific findings. As shaped by U.S. experts in film, video, broadcast, cable, and computer graphics, the SMPTE standard is an impressive accomplishment. And it's a giant step toward the goal of a universal standard for studio origination and international program exchange.

V. THE COMPATIBILITY WITH AND CONVERTIBILITY OF THE HDTV 1125/60 SYSTEM TO 1050/59.94, NTSC, PAL, SECAM AND FILM HAVE BEEN SUCCESSFULLY DEMONSTRATED.

The 1125/60 HDTV production standard represents the efforts of many in the television broadcast, program production and technical communities of the world to bring about an important concensus. The 1125/60 system, today, remains the only formal proposal before the CCIR, whose Study Group 11 has pronounced the format acceptable as a worldwide production standard. And following five years of intense study and debate, the SMPTE and ATSC have refined and totally defined the 1125/60 system, recommending that it be adopted as a U.S. voluntary standard for studio origination.

It has been demonstrated that 1125/60 accommodates the world's many television broadcast systems and distribution formats. This is implicit in the recommendation of 1125/60 by CCIR Study Group 11. It may be possible that 1050/59.94 will be among the many output signal formats which television studios of the future will have to provide. Should that prove to be the case, the choice of 1125/60 as an origination standard poses no difficulty because it can be shown that 1125/60 to 1050/59.94 conversion is a relatively simple matter.

The world's HDTV experts agree on one issue based on many psychophysical tests: any proposed HDTV production system should exceed 1,000 active television lines. The 1125/60 system retains 1035 active lines; it, therefore, meets this criterion. The 1125 line rate was chosen to facilitate simple digital conversion to both 525 and 625 lines, enhancing Hollywood exports to 625 countries. Engineers have an axiom: maintain signals at the highest quality level for as long as possible. This is a simple recognition of the fact that performance is easily diminished but rarely improved.

If, therefore, major programs are produced and delivered in the 1125/60 HDTV format, as they are expected to be, then local studios should retain these high level video signals throughout the plant. Local HDTV origination, recording, switching, and monitoring should all be done with 1125/60, in the interests of avoiding multiple formats in the studio and capitalizing on the economies of scale of universal equipments.

Initially, HDTV video signals will be analog, but there are good reasons to use digital audio signals from the start. Later, after the CCIR has expanded Recommendation 601 per the digital signal parameters of SMPTE 240M, the HDTV studios could go digital.

There is also a lesson to be learned from our experience in television studio operations. Twenty years ago, a television studio originated only 525-line NTSC composite color video signals and accompanying analog audio signals for network distribution and terrestrial broadcasting. News gathering was still done with 16mm film. Large switchers routed programs in every direction. Incoming

video signals from outside sources were particularly trying because these were not locked to local sync. The advent of digital synchronizers solved this vexing problem, and now we wonder how we ever managed without them.

The first synchronizer was a big, heavy box because the A/D converter itself typically occupied five inches of rack space. It cost as much as a good studio camera, so it was understandable if station engineers pointed with pride to their single digital synchronizer. Today, synchronizers are so affordable and numerous that we rarely give them any thought -- this thanks to economies of scale, VLSI, good engineering and competition.

Tomorrow's television studio will feed a myriad of signal formats to different media: 525-line NTSC for VHF-UHF terrestrial broadcasting; 525-line MAC type for Direct Broadcast Satellite; enhanced definition television (being developed); HDTV broadcast (a variety of possible ATV encoded systems); 1125/60 programs for syndication; 35mm film for syndication; and digital HDTV for future optical networks. Most of these formats will utilize conversion and transform circuits that should give us no more concern than the now ubiquitous synchronizer. This is not to underestimate or belittle the complexity of managing such a plant. It is clear, however, that matters would be considerably more simple, and certainly more cost effective, if the common format in the HDTV studio were to be the high-quality 1125/60 production standard employed on a broad scale across the many emerging U.S. electronic imaging industries.

The designers of some recently proposed ATV transmission systems

have suggested that the HDTV input signal to their respective encoders be a 1050/59.94 component video source. The rationale underlying this suggestion is compatibility with the existing 525/59.94 broadcast system. Could the 1125/60 production standard peacefully coexist with a 1050/59.94 ATV encoder front end? The answer is an unqualified yes.

Converting a 1125/60 signal to a 525/59.94 video signal is readily accomplished with excellent performance. Such a standards converter was demonstrated at the convention of the National Association of Broadcasters in April 1988.

In general, the conversion between two HDTV formats, or, for that matter, between any two formats of approximately equivalent resolution, e.g., NTSC and PAL, entails an unavoidable loss of picture quality. The filtering and re-sampling required inevitably produce artifacts.

The conversion from 1125/60 to 1050/59.94, however, represents a unique case, and the operational concepts of such a process have already been established. The key to simple spatial conversion is the use of cropping rather than line interpolation. Figure 1 shows the active raster area of the 1125/60 image (solid rectangle). The aspect ratio is 16:9, and there are 1035 active lines. The total line time is 29.63 μs and the active line time is 25.86 μs.

The 1050/59.94 system contains about 970 active lines. Total line time is 31.78 μs, and the active line time is 26.53 μs. The center 970 lines of the 1125/60 television image are used for the 1050/59.94 television image. This area is represented by the dashed rectangle. In order to retain a 16:9 aspect ratio, the sides are cropped by an

appropriate amount. The outer 3% border of the 1125/60 picture, shown diagonally shaded, is not reproduced in the 1050/59.94 picture. This compares to the film practice of always having a safety area.

First, each field of the 1125/60 video signal is transformed into a 1050/60 signal field by linear time stretching and blanking. Vertical and horizontal resolutions will decrease to 970/1035 or about 94%, as expected. Because interpolation and re-sampling are not used in this transformation, artifacts normally associated with these processes will be absent.

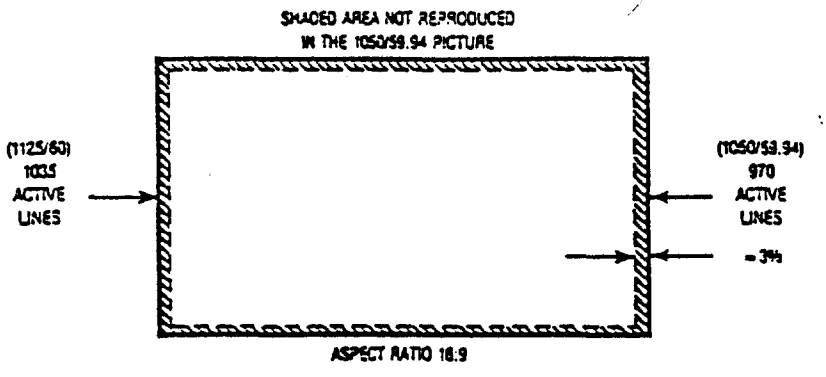

Figure 1. Spatial Conversion by Cropping

The next step is to convert the 1050/60 video signal to a 1050/59.94 signal. As these two field frequencies are extremely close, field rate conversion using interpolation is unnecessary. One could use a synchronizer (modified to operate with higher bandwidths and lines of 1050/60) to skip a frame every 33 seconds, but this would cause motion to become erratic during that instant.

To deal with this problem, a new type of synchronizer has been developed with a large buffer memory and a motion detector to prevent frame skips whenever motion is present in the picture. Figure 2 is a

block diagram of this concept adapted for converting 1050/60 to 1050/59.94. Frame difference information from the frame delay is used to establish the existence and amount of motion. Scene cuts are detected by using the first derivative with respect to time of the motion signal.

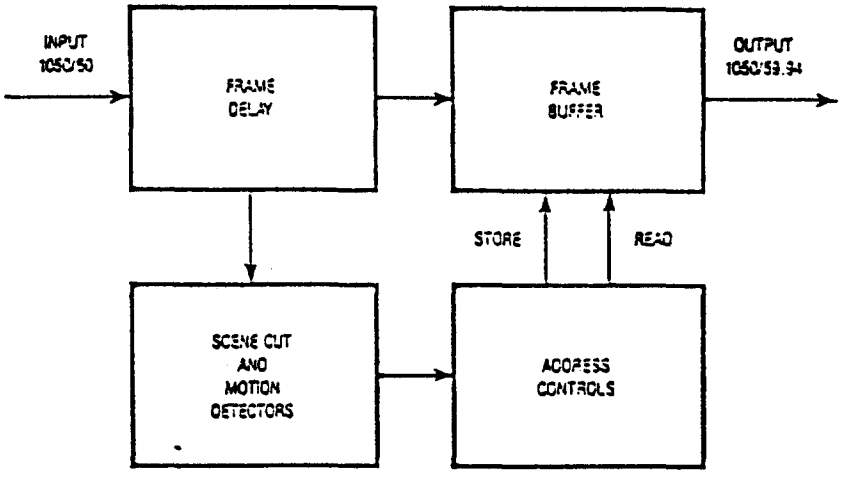

Figure 2. 1050/60 to 1050/59.94 Converter

Frame skips are executed according to an algorithm. When a frame skip becomes necessary to restore synchronization, it is executed when one of the following conditions is satisfied: (1) when there is no motion in the picture, (2) when there is a scene cut, (3) when the area in motion is relatively small, (4) when the frame buffer is about to overflow. Condition 4 would be an extremely rare occurrence in ordinary programs. If, however, this poses a problem, then the buffer could be enlarged to decrease the probability of reaching condition 4.

Program sound must be processed to maintain lip-sync with the picture. A skipped frame represents a sudden time shift of about 33ms, even though the average time change is only 0.1%. Low-cost audio synchronizers are readily available to cope with these shifts.

A simpler way to perform 60 to 59.94 field rate conversion (if working in real-time is not necessary) would be to record the 1050/60 program on a VTR and play it timed to 1050/59.94. There would be no dropped frames, and audio would remain synchronized with the picture. The duration of the program, however, would increase by 0.1% and the pitch of the sound would decrease by the same amount. Means are available to compensate for these artifacts.

Clearly, the conversion of 1125/60 to 1050/59.94 is well within the scope of existing technology. And, to put things in perspective, it should be observed that an 1125/60 to 1050/59.94 converter incorporated within an already quite complex ATV transmission encoder hardly represents a major technical obstacle.

The concept of a single worldwide production standard is of such great consequence that it is difficult to visualize the industry without one. The 525-line NTSC service will certainly continue to be widely used for the next ten years and far beyond. One can expect present-day 525-line NTSC facilities to remain separate from the evolving HDTV studios. The latter will originate some HDTV programs, but most will come from producers in Hollywood and elsewhere. If, as expected, these programs are originated in the 1125/60 format, then it would make good sense to maintain this high-quality signal level for as long as possible throughout the studio before finally encoding to a future ATV transmission signal format.

Tomorrow's television studio will be required to provide a wide variety of signal formats to sundry media. Conversion from 1125/60 to these specialized formats can be accomplished with ease at the output

feeds. If one of these output feeds necessitates 1050/59.94, we have shown that good results can be provided by a relatively simple converter.

An HDTV studio will be capital intensive, and broadcasters wish to avoid exorbitant start-up costs. The surest way to accomplish this is to buy equipment adhering to a widely used standard from vigorously competing manufacturers.

VI. CONCLUSION

In a few short years, HDTV 1125/60 has progressed from closed-circuit demonstrations and testing of prototypes to emergence as the most complete system for high definition studio origination and program exchange. And HDTV 1125/60 is the only such system currently in production.

Respectfully submitted,

William G. Connolly